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(54) Title: A SYSTEM FOR CONVERTING HIGH-LEVEL COMPUTER LANGUAGES INTO SPECIFIC LOW-LEVEL LANGUAGES OF DIGITAL SIGNAL PROCESSORS

(57) Abstract

A computer-application multi converter system for converting computer applications high-level languages into DSP low-level commands is disclosed. The system includes a PC host and a compiler, loader, and pre-programmed command tables resident on the PC host. A DSP test-board is connected to the PC host bus. A debugger tool resides partly on PCT host memory and partly on DSP test board memory. The compiler reads high-level commands from a computer-application developer-file and locates them in the pre-programmed command tables within the PC memory to respectively select from the tables low-level commands analogue to the read high-level commands and relate to a specific type of target DSP. The analog low-level commands are transferred to DSP memory with the loader and with the PC host bus. The DSP test-board has a circuit board with contacts adapted for placing, energizing and communicating with at least one target DSP. There is also a memory for storing low-level commands received from the compiler through the loader and PC host bus. Memories provided for storing pre-programmed DSP functional-libraries and execution-control-program runs and debugs machine-applications based on the low-level commands on the target DSP while using the debugger tool and pre-preprogrammed routines from the DSP functional-libraries.

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A SYSTEM FOR CONVERTING HIGH-LEVEL COMPUTER LANGUAGES INTO SPECIFIC LOW-LEVEL LANGUAGES OF DIGITAL SIGNAL PROCESSORS

Field of the invention:

The present invention relates to an automatic computer-application multi converter system for the use of engineers and developers of DSP based products (DSP = Data Signal Processor). The multi converter system according to the present invention automatically converts and adapts computer applications written in high-level languages into low-level DSP commands of the specific DSP types in use. Thus, the multi converter system according to the present invention effectively eliminates the need for DSP-specific coding.

Background of the invention:

At present, application developers use a high-level algorithm development environment (such as MATHWORKS Inc. MATLAB®, National Instruments CVI, Microsoft Visual C) to carry out math and visualization functionality, as well as simulate editing and debugging functions. At the end of the simulation an "outline" or algorithm is developed for the DSP-engineering team.

The engineers would then have to methodically perform a manual mapping between the algorithm and the DSP language. Coding would begin for the target DSP in it's "native" low-level language where very few visualization aids exist.

Therefore, the involvement of a specialist skilled in both (i.e. high-level and low level) languages is essential whenever a high-level language

computer-application is directed to a new type of DSP intending to use that application. The translation processes are costly in terms of time and money thus increase the selling-prices of computer-applications and delay their publication.

The computer-application multi converter system according to the present invention is a novel highly evolved system that provides a fast and efficient means for the development of applications for DSP-based systems which can be multiprocessed, and extremely reduces the amount of manual-work involved in converting high-level-written computer-applications into low-level DSP commands.

Using this present invented system, developers may simply continue working in their same familiar high-level development environment, where the output is no longer in the form of a specification. Instead, output is in the form of robust DSP applications, compiled, debugged and tested directly on the target machine, essentially eliminating an entire phase within the development process.

Summary of the invention:

In the context of the present invention:

The terms "high-level language", "high-level command", relate respectively to a computer language or command written in computer language used by application developers in the initial of application development, before directing the application to specific machines.

The term "DSP" relates to "Digital Signal Processor" meaning a chip using for digital signal processing.

The terms "low-level language", "low-level command", relate respectively to a language or command using for controlling and operating a specific DSP type.

The term "developer-file" relates to an electronic file of algorithm (or series of algorithms) written in a high-level computer language, as outlined by an application developer.

The term "PC" relates to a computer unit (not necessarily Personal Computer) adapted to host a system according to the present invention.

The term "target-DSP" relates to any specific DSP type for which a high-level application is currently converted into low-level commands by the invented system.

The term "DSP- test-board" relates to any kind of circuitry which host at least one target-DSP chip either if it is manufactured for a dedicate testing purpose (such as performed by a system according to the present invention) or for the practical (every-day) use of the target-DSP which on that board is constantly resides for current use.

The term "DSP-functional-libraries" relates to pre-programmed routines resident on a memory means of the DSP-test-board and optimized for running various mathematical algorithms and control functions.

The present invention relates to a computer-application multi-converter system for converting computer applications of high-level languages into DSP low-level commands, consists of:

(a) PC host;

(b) compiler, loader and pre-programmed command tables resident

on the PC host;

(c) DSP-test-board connected to the PC host bus;

(d) debugger tool residing partly on memory means of the PC host and partly on memory means of the DSP-test-board;

wherein the compiler has means for reading high-level commands from a computer-application developer-file, locate them in the pre-programmed command-tables within the PC memory, respectively select from said tables low-level commands analogue to the read high-level commands and relate to a specific type of target DSP, and transfer the said analogue low-level commands to memory means of the DSP by means of the loader and through the PC-host bus;

and wherein the DSP-test-board is comprising a circuit-board with contacts adapted for placing, energizing and communicating with at least one target-DSP, memory means for storing low-level commands received from the compiler through the loader-means and PC-host bus, memory means for storing pre-programmed DSP-functional-libraries, and an execution-control-program having means for running and debugging machine-applications based on said low-level commands on the target DSP while using the debugger tool and pre-programmed routines from the DSP-functional-libraries.

The concept of translating higher level language statements and commands into fully executable command-tables directly for a target-DSP, is unique. This is not a conventional cross-compiler which translates from one assembly language to another. It is rather a distinctive DSP development environment which is able to translate entire functions and commands into DSP code while maximizing the

uniqueness of DSP architecture and capabilities.

The system according to the present invention intelligently exploits the powerful architecture of the DSP's which can natively perform many functions in hardware.

As an example, multiplication in MATLAB (on a Pentium processor) would normally translate to accumulate and shifts on Pentium C code. A conventional cross-compiler, would translate the Pentium C to DSP C essentially losing the inherent advantages of the DSP (including multiprocessing capabilities) . The code would be so inefficient that for most applications the results would be unacceptable. The "multiply" function is among many which are primitive operations for the DSP and therefore can be executed many times faster when released from the constraints of traditional Pentium and single-processor programming structures.

In a system according to the present invention, the "multiply" command is translated to a table which runs the pre-constructed DSP-functional-libraries on the target-DSP.

In addition, the concept of the present invention offers a programming capability, which generates optimized code for complex functions on multiprocessing DSP's while also offering the advanced man-machine-interface, simulation and graphic debug capability of the PC-resident higher level environment.

According to another embodiment, the system according to the present invention is adapted for offering extensions to the conventional high level algorithm development environments. This allows the application developer to easily integrate multi processing capabilities (not available

in traditional environments). The instructions of this extended embodiment of the present invention are introduced at the high-level environment phase, enabling developers to allocate processing tasks to specific components and processors even in the most complex multiprocessing target machines.

The system according to the present invention allows the developer to carry out all of the functions of DSP application development, testing, and implementation directly from the high-level development environment onto the target machine. This enables engineers to develop applications more quickly than ever before. Using the system according to the present invention, developers may simply continue working in the same familiar high level development environment, where the output is no longer in the form of a specification. Instead, output is in the form of robust DSP applications, compiled, debugged and tested directly on the target machine, essentially eliminating an entire phase within the development process.

As a corollary to this, data output from the DSPs can return as high-level language variables and be further processed or displayed using a high-level graphical user interface. Applications designed to run on a multiprocessing target machine have traditionally been significantly more difficult to develop than conventional (already complex) DSP applications. The system according to the present invention bridges the gap between generic graphical algorithm development packages and the cryptic code specific to each type of DSP.

Detailed description of the invention:

The present invention will be further described by figures 1-2. These

Figures (and associate text) are solely intend to illustrate a preferred embodiment of the invention and in no manner intend to limit the scope of the invention.

Brief description of the Figures:

Figure 1 illustrates in block diagram the present art in the field of converting high-level computer application into low-level commands of specific DSP type.

Figure 2 is a block diagram of a system for converting various computer applications written in different high-level languages into low-level commands of various specific DSP types, according to the present invention.

Detailed description of the Figures:

Figure 1 illustrates in block diagram the present art in the field of converting high-level computer application into low-level commands of specific DSP type. Application developers use a higher level algorithm development environment (1) (such as MATHWORKS Inc. MATLAB®, National Instruments CVI, Microsoft Visual C) to carry out math and visualization functionality (2), as well as simulate editing and debugging functions (3).

At the end of the simulation an "outline" or algorithm (4) is developed for the DSP-engineering team. The engineers would then have to methodically perform a manual mapping (5) between the algorithm (written in high-level language) and the DSP (low-level) language. Coding would begin for the target-DSP in it's native language where very few visualization aids exist. The result of this process would be a

DSP-language command-list which must be compiled (7), debugged (8) and corrected (9) correspondingly, for several times. In the end of this process a testing-phase (10) could be performed by running the corrected low-level language edition on the target-DSP.

This above mentioned manual-work has to be recurrently processed for each separate DSP type intending to use the specific high-level written application.

Figure 2 is a block diagram of a system for automatically converting various computer applications written in different high-level languages into low-level commands of various specific DSP types, according to the present invention. As will be further understood, the time-intensive manual-work depicted by steps (5)(6)(7)(8) and (9) of Figure 1, is eliminated while taking the advantage of a system according to the present invention. The system according to the present invention is comprised of a PC host (11) having compiler (13) which reads high-level-language statements from a developer-file (12), locates them in pre-loaded command-tables (14) and respectively selects and draw-out from said command-tables (14) low-level DSP commands analogue to the read high-level statements and relate to the specific type of target-DSP (as selected in advance by the system user/operator), and transfers them by means of loader (15) through the PC bus (16) to the DSP-test-board (17).

The DSP-test-board (17) consists of a target-DSP chip (18), a memory (19) (preferably the DSP flash-memory) and DSP-function-libraries (20).

The output of the loader (15) (the "product" of the conversion path) transferred through the bus (16) is loaded to region (19a) of the memory

(19) creating a specific command table adapted to the specific target-DSP (18). An execution-control-program transferred from the PC-host (1) through the bus (16) is located in region (19b) of the memory (19). This execution-control-program which resides in the memory (which is preferably the flash-memory of the target-DSP chip itself) is specific to the DSP-type chip. The execution-control-program (19b) carries-out the commands within the command-tables (19b) by calling pre-programmed functions from the DSP-function-libraries (20) which are pre-programmed routines optimized for running various mathematical algorithms and control functions.

Claims:

1. A computer-application multi-converter system for converting computer applications of high-level languages into DSP low-level commands, consists of:

(a) PC host;

(b) compiler, loader and pre-programmed command tables resident on the PC host;

(c) DSP-test-board connected to the PC host bus;

(d) debugger tool residing partly on memory means of the PC host and partly on memory means of the DSP-test-board;

wherein the compiler has means for reading high-level commands from a computer-application developer-file, locate them in the pre-programmed command-tables within the PC memory, respectively select from said tables low-level commands analogue to the read high-level commands and relate to a specific type of target DSP, and transfer the said analogue low-level commands to memory means of the DSP by means of the loader and through the PC-host bus;

and wherein the DSP-test-board is comprising a circuit-board with contacts adapted for placing, energizing and communicating with at least one target-DSP, memory means for storing low-level commands received from the compiler through the loader-means and PC-host bus, memory means for storing pre-programmed DSP-functional-libraries, and an execution-control-program having

means for running and debugging machine-applications based on said low-level commands on the target DSP while using the debugger tool and pre-programmed routines from the DSP-functional-libraries.

2. A computer-application multi-converter system for converting computer applications of high-level languages into DSP low-level commands, wherein the DSP-test-board is a circuit-board on which at least one DSP is constantly resides for its current use.

3. A computer-application multi-converter system for converting computer applications of high-level languages into DSP low-level commands as herein before described and illustrated.

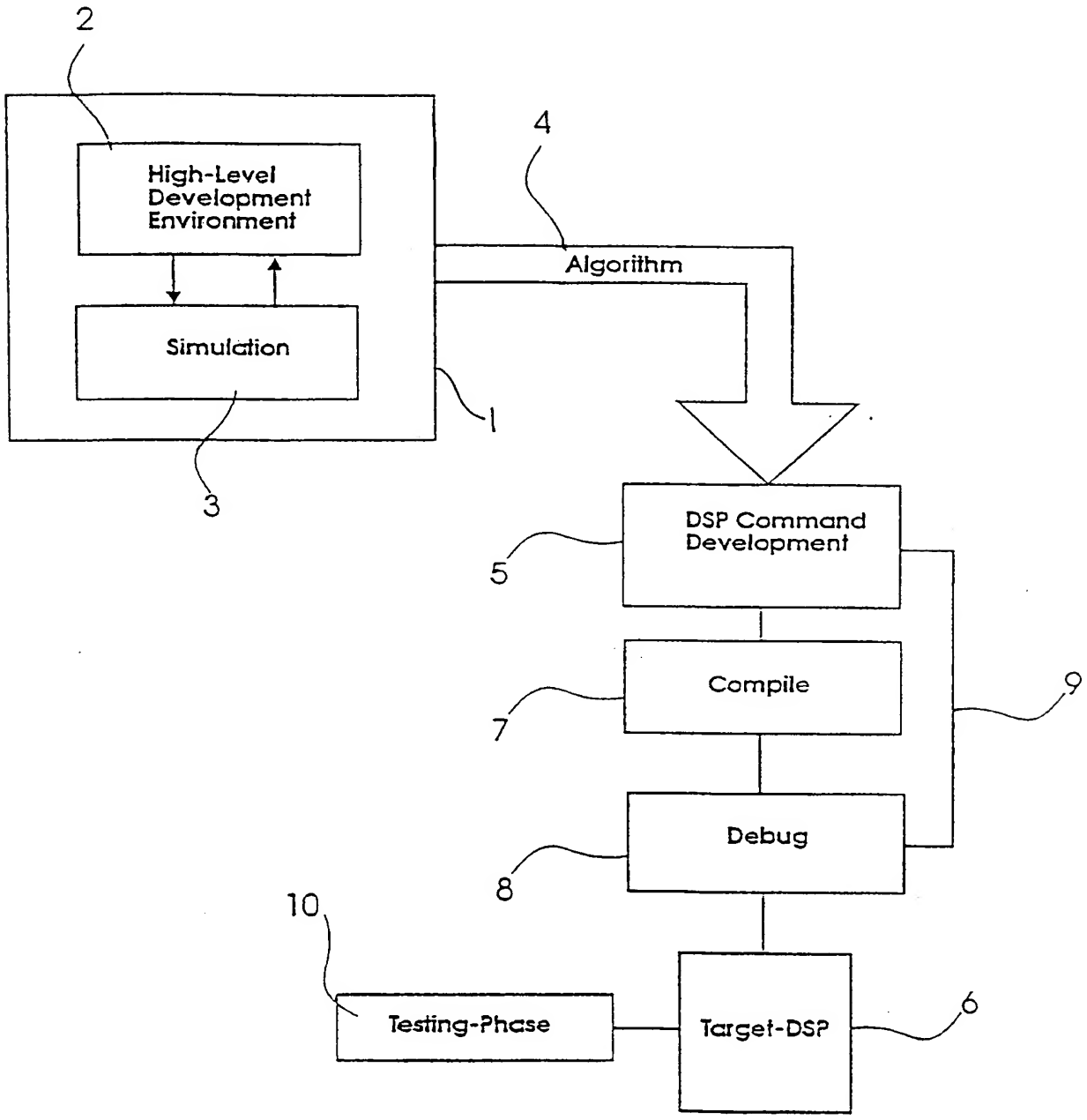
2
High-Level Development Environment
Simulation
3
1
4
Algorithm
DSP Command Development
5
Compile
7
9
Debug
8
10
Testing-Phase
Target-DSP
6

FIGURE 1

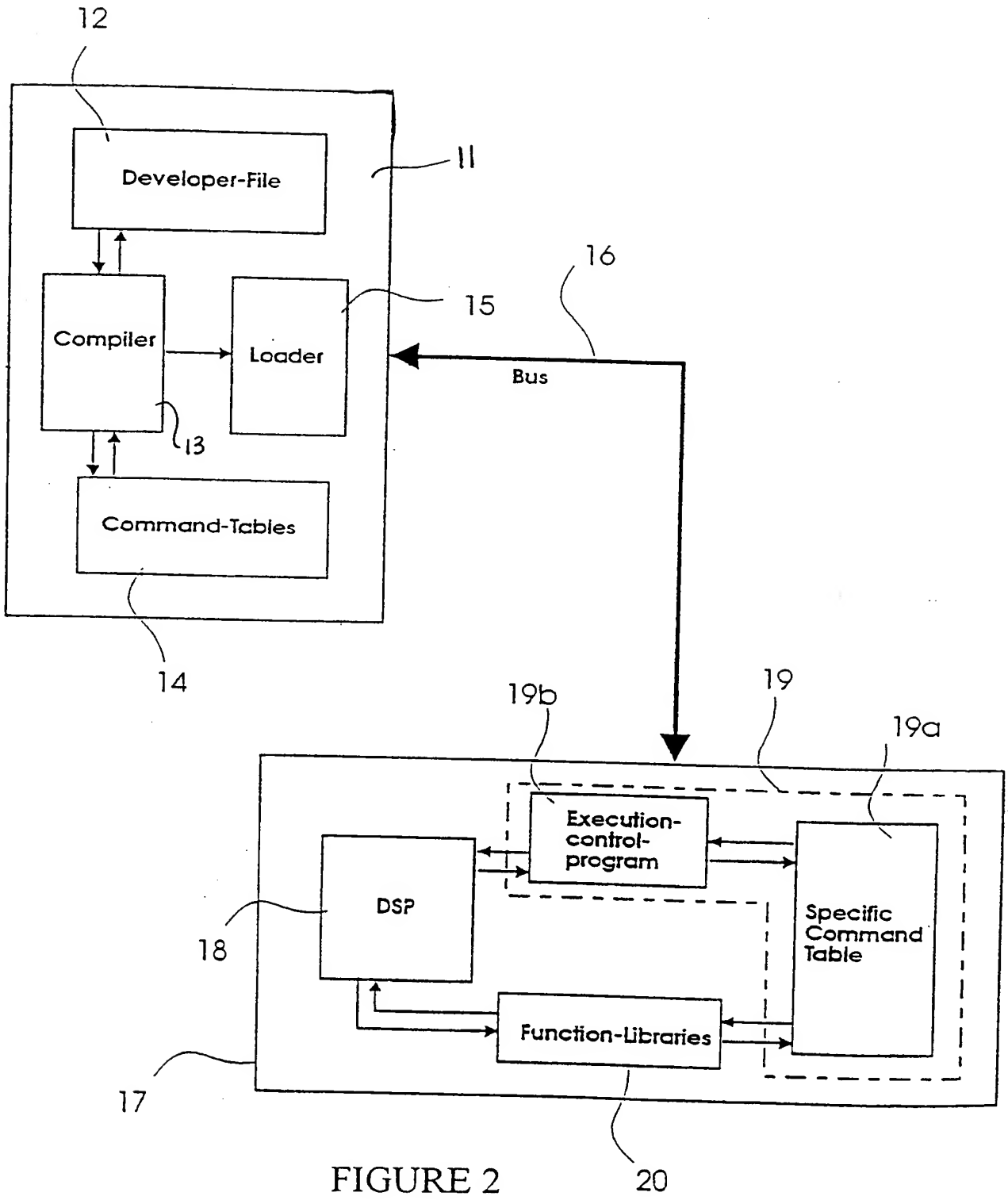
12
Developer-File
11
16
15
Compiler
Loader
Bus
13
Command-Tables
14
19b
19
19a
Execution-control-program
DSP
18
Specific Command Table
Function-Libraries
17
20

FIGURE 2

INTERNATIONAL SEARCH REPORT

Int ational Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G06F11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CLAYTON M: "INTEGRATED DEVELOPMENT TOOLS FOR DSP" ELECTRO INTERNATIONAL CONFERENCE RECORD,US,WESTERN PERIODICALS CO, VENTURA, CA, vol. 18, 1 January 1993 (1993-01-01), pages 100-105, XP000381906 the whole document ---	1,2
Y	US 5 394 544 A (MOTOYAMA TETSURO ET AL) 28 February 1995 (1995-02-28) column 2, line 65 -column 3, line 2 column 3, line 15 - line 20 column 6, line 3 - line 6 claims 1,5,6 --- -/--	1,2

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	"SPOXWorks connects MathWorks DSP Workshop and DSP hardware" MATLAB NEWS & NOTES, 'Online! 1998, XP002140489 Retrieved from the Internet: <URL:http://www.mathworks.com/company/newsletter/win98/win98spox.shtml> 'retrieved on 2000-06-19! the whole document ---	1,2
A	"Press Release: Mango DSP, Ltd, launches its latest Engineering Development System, Mango Math-Link EDS" MANGO WEB SITE, 'Online! 10 July 1998 (1998-07-10), XP002140490 Retrieved from the Internet: <URL:http://www.mangocom.com/news3.htm> 'retrieved on 2000-06-19! the whole document ---	1,2
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1

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Information on patent family members

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US 5394544 A	28-02-1995	NONE	